Promoting Interactive Learning with an Electronic Student Response System

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Abstract

University instructors have long struggled to incorporate problem solving exercises and meaningful question/answer sessions into the traditional lecture format, particularly in large-enrollment courses. One promising alternative for creating a more interactive, student-centered classroom is provided by electronic response systems (ERS). Similar systems have been used for several years, primarily in physics and engineering departments. A number of recent publications have analyzed ERS and their efficacy in this setting (e.g., Hake, 1998; Crouch and Mazur, 2001). However, the use of ERS has not spread widely to other disciplines and there is little research on its effectiveness in these other disciplines. The purpose of this paper is to summarize the experiences with implementing ERS in an Agricultural Intermediate Microeconomics course and to further the body of literature analyzing the effectiveness of using ERS in college classrooms. In general, the burden of using ERS remains somewhat heavy due to software inadequacies, but the response from students has been quite positive, with a large majority of students considering ERS-enhanced lectures to be more enjoyable and effective than traditional lectures.

Introduction

The world we live in is a learning environment more interactive than what traditional classroom lectures provide. Thus, not surprisingly, teaching methods employing an active or interactive approach often prove more effective than traditional lectures. For example, evidence suggests that, for many students, traditional lectures are not effective for constructing conceptual understanding (Meltzer and Manivannan, 2002; Bonwell and Eison, 1991), while active learning has been found to boost development of critical thinking skills (Borg and Borg, 2001; Youngblood and Beitz, 2001; Slavin, 1996), improve student understanding and retention of material (Oliver-Hoyo, et al., 2004; O'Sullivan and Copper, 2003; McClanahan and McClanahan, 2002; Hinde and Kovac, 2001; Yuretich, et al., 2001; McCarthy and Anderson, 2000), and engender a more positive attitude about the subject (Hinde and Kovac, 2001; Yuretich, et al., 2001). Yet, the lecture remains the predominant method of instruction on most college campuses (Buchanan, 1998), at least partly due to the advantages it provides in terms of covering large amounts of material in a relatively short period of time (Cashin, 1990). A second advantage of the lecture format is that it is not as adversely affected by large class enrollments as other teaching methods. Lecture-based courses are particularly prevalent in first and second year courses where enrollments can reach into the hundreds. Thus, lectures are often exclusively employed in large-enrollment classes and increases in student numbers, brought about by the recent increase in access to higher education, have further tilted the balance in favor of lectures, largely at the expense of seminars and tutorials (Hensley and Oakley, 1998; Tinto, 1993).

Criticisms of the lecture format often revolve around the passive role played by students and the lack of student teacher interaction. Pedagogical methods that allow both student teacher interaction and an opportunity for the student to "think about" the subject and discuss and identify misconceptions are valued because the process of internally reconstructing the learnt material is an important part of the learning process and it is this part of the learning process that is not normally part of the traditional lecture. Although many techniques can be used to get students actively involved, including "experimental learning, cooperative learning, problem-solving exercises, writing tasks, speaking activities, class discussion, case-study methods, simulations, role-playing, peer teaching, fieldwork, independent study, library assignments, computer-aided instruction, and homework (Houston, 1995, p. 8)," these techniques are often resource-intensive and difficult to employ in courses with large enrollments. For example, anyone who has taught a large-enrollment class knows how difficult it is to generate useful class discussion of course topics or to stimulate interactive consideration of what, in the absence of such discussion, essentially becomes a rhetorical question. "A general 'Are there any questions?' is not likely to be as effective as asking some particular question of your own in a non-threatening manner. Rather than singling out a particular student, you might put a question on the board or the overhead projector and have the whole class meditate on the answer for a minute or so before discussing it in detail" (Saunders and Welsh, 1990, p. 114).

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Thus, while the benefits of active learning, which is broadly defined to include any learning activity engaged in by students in a classroom other than listening passively to an instructor's lecture (Truscott et al., 2000; Bonwell and Eison, 1991), are well-known (Ragains, 1995), the problem lies in finding relatively inexpensive ways to incorporate these techniques into college courses, including large-enrollment classes. Solving this problem could have substantial benefits, as the flexibility of active learning techniques means that they can be employed in a variety of classroom contexts, for a variety of purposes (e.g., attendance checks), and for virtually any subject area across virtually any discipline (Hake, 1998; Wright et al., 1998; Sokoloff and Thornton, 1997).

This paper is concerned with one possible solution to this problem the use of an electronic response system. These systems have the potential to provide a relatively inexpensive means of incorporating at least limited active learning techniques in even the largest classes. Thus, the following offers a brief overview of electronic response systems and the role they can play in promoting active learning, along with a discussion of the initial experiences of one department in adopting and using one of these systems.

Electronic Response Systems

While there are a variety of ERS on the market, the basic components of these systems do not vary substantially from one variety to another. All are comprised of five basic components, the first three of which are purchased with the system—wireless transmitters, receivers, and computer software. The last two—personal computer and digital projector—are provided by the institution. Each student is given one wireless transmitter, which, for some systems, have the capacity to answer questions with up to 10 different choices. Using the ERS software, a question or prompt is loaded into the computer and displayed to the class via the digital projector. Students then have a predetermined amount of time to respond to the question or prompt using the transmitters, which closely resemble a television remote. The students respond to the questions by aiming the transmitter at one of the receivers around the classroom. The receivers (one for every 25 - 40 transmitters) collect the responses and transmit them to the computer. Each time that a response is recorded, a box on the display changes color. Since each transmitter is encoded with a unique sender ID number, the box in the response chart shows information that identifies the sender (Figure 1) and the student can determine when his or her answer has been recorded. Finally, the instructor has the flexibility to display only the information (student first name, last name, nickname, student ID number, or transmitter ID number) they choose. The response itself is not displayed. At the end of the question period, a statistical summary of the responses received can be shown as a histogram (Figure 2), either automatically or with a keystroke. At the end of the session, the results can be written onto the computer's hard disk or other memory unit for subsequent retrieval.

In addition, there are a number of options with how the system is used. For instance, for one particular variety, the instructor can also ask the student to transmit their degree of confidence (high, neutral, or low) in the answer provided. Also, the systems allow the instructor to choose between an Anonymous Mode, where no records of individual responses are kept, or a Known Mode, where each student's response is individually recorded on a data file for further examination. In Known Mode, each ID-tagged response is recorded in a data file in the sequence received. The cycle is repeated for each question until the end of the session. At that time, the

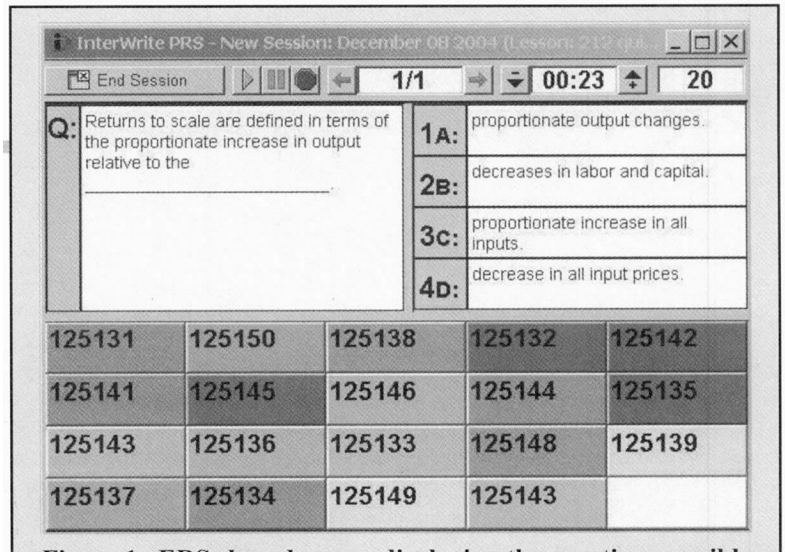

Figure 1. ERS shared screen displaying the question, possible responses, list of student ID numbers, student response status and the time remaining.

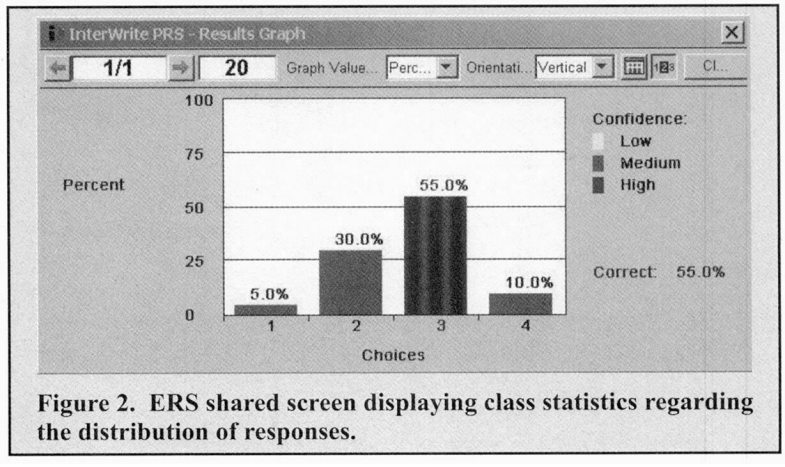

Figure 2. ERS shared screen displaying class statistics regarding the distribution of responses.

individual student responses can be marked (graded). The results can be saved into the grade book or imported into excel or other popular third-party grade book applications.

Setting up classes, quizzes, and lessons with the software is fairly simple. The software provides a very simple and intuitive interface to create questions. The software allows you to select the number of answers, identify the correct answer, and set the time limit for students to answer the question. In addition to typing in questions, you can also import industry standard XML format questions and their corresponding correct answer from various sources, including many book publishers. The software also includes a PowerPoint add-in that allows you to turn any PowerPoint slide into an ERS question slide. The simplicity of the software makes it easy to set up and easy to use. The response grid, shown in the Session Window (Figure 1), can be changed to fit your class size and will respond with the numeric transmitter code, student ID, student first name or last name.

The ERS method offers a number of possible advantages. First and foremost, the method allows the whole class to participate regardless of class size. It also provides an instantaneous assessment of student comprehension as well as instructor effectiveness. The method also allows students to personally evaluate their own performance and reflect upon the material. Since the results of class questioning can be stored to file and assessed at a later stage, an ERS can allow an instructor to monitor class or individual student progress. Previous research suggests that the use of ERS can lead to the following positive impacts:

1. Student's willingness to engage in discussion after they saw that others had the same opinion as they do (Nolen, 2003).
2. Instructor ability to identify students who were having difficulty following material prior to any formalized testing (Nolen, 2003).
3. Increased ability of instructor to gauge student understanding of presented material and adapt presentation to suit needs of class (Elliott, 2003).
4. Increased ability of students to gauge their own understanding of material and compare it with others (Elliott, 2003).
5. Stimulated interest in, concentration during, and enjoyment of, lectures (Elliott, 2003).
6. Student evaluations revealed that they found it "easy to use," that it "increased [their] enjoyment of lectures," and "helped [their] concentration levels in lectures." Less support for notion that ERS encouraged student attendance at lectures, possibly because many believed they would have gone anyway (Elliott, 2003).
7. Increased student participation over show of hands approach to discussions (University of California, 2004).

In recent years, several approaches have been introduced to try to initiate problem solving and question/answer sessions into the traditional lecture. Dufresne, et al. (1996) tout the use of electronic response systems (ERS) as an 'emerging technology' that offers a promising tool for helping instructors create a more interactive, student-centered classroom. Judson and Sawada (2002) present a more in-depth review of ERS dating back to the 1950's. Similar systems have been used for several years in the USA and Hong Kong, primarily in Physics and Engineering (Draper et al., 2002; Cue, 1998; Bessler, 1969; Boardman, 1968). The method and its efficacy in these applications have been described in several publications (Draper et al., 2002; Hake, 1998; Crouch and Mazur, 2001). That ERS should have gained initial popularity in these disciplines is not surprising, given that the teaching in these subjects is largely "concept" led with an emphasis on understanding these concepts, a style of teaching for which ERS is particularly well-suited.

Our Experiences with ERS

The authors first became aware of ERS while attending a presentation on innovative technology for the classroom at the Southern Region Teaching Symposium conference in 2002. Impressed by the potential of this technology, we set out to acquire a system and put this technology to work. Funds for purchasing the system were provided by The University of Tennessee College of Agricultural Sciences and Natural Resources' Neal and Tacie Peacock Endowment Fund. After considering the different varieties then on the market, the Department of Agricultural Economics adopted the Personal Response System developed by Educue.

Enough receivers were purchased to permanently equip one classroom with ERS and also to have a portable system that can be set up in any classroom with minimal effort. One concern with the system involves distribution of the wireless transmitters to the students. There are a number of different possible arrangements, as evidenced by a quick internet search for existing uses of the system. For example, the physics department at Harvard and the engineering department at MIT loan the transmitters to students enrolled in courses using the system for the semester and charge students who fail to return the transmitter at the end of the semester. At UC Berkeley, Rutgers and Arizona State, students buy the transmitter from the bookstore ($40 - $48) and the bookstore buys them back after use ($20 - $24). At Colgate students borrow a transmitter every time they come to class. While there is some concern that allowing students to borrow a transmitter each time they come to class might lead to transmitter dissipation, at least one case study has not found this to be the case (Elliott, 2003). At least initially, we are simply distributing the transmitters before each class.

The ERS was initially used to administer quizzes in a section of Intermediate Microeconomics in the Fall of 2003. These unannounced quizzes occurred at least once a week at various points during class lectures. The quizzes typically consisted of two or three, primarily quantitative questions, and correct answers were provided and discussed at the conclusion of the quiz. ERS has since been used in sections of Introduction to Agribusiness and Farm Management. Uses of ERS in Introduction to Agribusiness and Farm Management included attendance, quizzes and enhanced lectures by integrating questions after fundamental material had been covered in class. In an attempt to evaluate the effect of using ERS, we surveyed the students enrolled in Intermediate Microeconomics.

To gauge student evaluation of the usefulness of ERS, the authors constructed a questionnaire that was designed to resemble the questions and question formats employed by the University for student course evaluations. Thirty-two of these questionnaires were handed out at the end of the Fall 2003 Intermediate Microeconomics course with 100% completion and return rate. No effort was made to validate the questionnaire. The questionnaire consisted of fifteen questions with each containing five statements to which students could respond by selecting answers 1 to 5, 1 indicating strongly agree and 5 denoting strongly disagree. Students were also given the opportunity to add any additional comments at the bottom of the questionnaire. A summary of the responses is provided in Table 1. None of the students had experienced more than one semester of teaching with ERS when the questionnaire was prepared. Thus, these results may change as students complete more courses taught with ERS and/or instructors become more proficient in its use. Also, it is difficult to know how other uses of the ERS would affect student perceptions of the technology. In any event, for the students in this class, ERS seemed to be a positive experience. Few students had difficulty in using the system or found it embarrassing and the great majority of students stated that they always responded to the questions.

The student evaluations seem to suggest that the most favorable aspect of ERS use was its performance as a diagnostic tool, with a mean response of 2.469 and a majority (62%) asserting that ERS helped them to evaluate their understanding of the material. To the statement 'The PRS questions allowed the instructor to evaluate how well the class understood the subject matter' the mean response was 2.125 with 82% choosing strongly agree or agree. Yet, only 9% believed that use of the technology improved their exam scores with a mean response of 3.594. Otherwise, the students were relatively neutral in their evaluations, with large percentages of students declaring themselves undecided in response to many of the remaining questions. For example, fully half of the students were undecided on whether use of ERS improved their understanding of the material or kept their attention focused on the subject matter with a mean response of 2.969 and 2.906 respectively. However, in general the students seemed to favor use of ERS. Thus, 47% of students felt that ERS use in other courses should be increased, while only 15% felt

Table 1. Summary results of the student questionnaire from Intermediate Microeconomics course

Question	Strongly Agree (1)	Agree (2)	Undecided (3)	Disagree (4)	Strongly Disagree (5)	Mean*
	----------Percentage----------					
The ERS handsets difficult to use.	0	9	3	72	16	3.938
I often had difficulty in getting the ERS to accept my response.	3	13	9	72	3	3.594
I often had difficulty knowing or seeing the ERS question being asked.	0	28	9	53	9	3.438
I always responded to the ERS questions asked in lecture.	59	34	0	6	0	1.531
Using the ERS handset was embarrassing.	0	3	13	31	53	4.344
Responding to the ERS questions kept my attention focused on subject matter	6	22	50	19	3	2.906
Responding to the ERS questions improved my understanding of the subject matter.	3	25	50	16	6	2.969
The ERS questions allowed me to evaluate how well I understood the subject matter.	6	56	25	9	3	2.469
The ERS questions allowed the instructor to evaluate how well the class understood the subject matter.	16	66	9	9	0	2.125
Responding to the ERS questions improved my exam scores.	3	6	28	53	9	3.594
I would like to see ERS used in other classes.	0	47	38	9	6	2.750
Individual responses to the ERS questions should be recorded and graded.	0	38	34	25	3	2.938
Lectures using ERS are more enjoyable than traditional lectures.	0	44	44	12	0	2.688
ERS is a useful tool for student learning.	3	59	25	13	0	2.469
ERS is a poor use of class time.	3	9	31	56	0	3.406

that it should not (mean response of 2.75). Similarly, while only 44% of students believed that their enjoyment of lectures supplemented with ERS was greater than traditional lectures, only 12% believed that it was not. Fifty-six percent disagreed that ERS was a poor use of class time, while only 12% agreed. Perhaps most encouragingly, a majority of the students felt that ERS was a useful tool for student learning and that it made lectures more enjoyable with mean responses of 2.469 and 2.688 respectively. A significant percentage (38%) of students was in favor of individual responses being recorded.

Students were also given an opportunity to provide open-ended comments. In doing so, a couple of students stated that they would forget to turn on the handset before a question was posed to the class making it difficult for them to respond without some stress related to the time limit placed on answering the question. Another common reply addressed the problem of student confusion when the answer to a question was displayed. In many cases there was no 'correct' answer given and many students felt they would like to see a clearer answer to the question. A further negative aspect, which was commented on several times, was the feeling that the system had too many problems which negatively impacted the students' ability to gain knowledge and should be reduced to the start and end of a topic as a reinforcing mechanism.

Summary

The overall response from students to the use of ERS has been positive. There is general agreement that lectures are more enjoyable and learning is enhanced when ERS is used to supplement the traditional lecture. Also, students recognized the value of ERS in allowing them and their instructor to evaluate their understanding of the subject matter. Thus, these results generally support the idea that electronic response systems can be an effective classroom-management tool that allows instructors to create a livelier and richer learning environment. ERS can enhance communication among students and between students and the instructor, increasing engagement during class and affecting both learning and instruction. As a result of improved student-instructor interactions, instructors can tailor lectures to meet a wider range of student needs. However, the eventual value of ERS as a teaching aid, will depend upon the amount of time that faculty have to devote to using new technology. Implementing new teaching strategies with these technologies requires thoughtful preparation time similar to that required when preparing a "new" course. Despite these factors, which might discourage someone from using an ERS, we remain optimistic about its potential to supplement, if not transform, the traditional lecture. Our results, together with those of others in the constantly growing literature on active learning through the use of an electronic response system, should be encouraging to both those considering the use of active learning techniques for the first time and those already using them.

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